

His facts are:—Huggins finds the wave-length in the Orion nebula as 5004·75, the magnesium fluting being 5006·5, a difference of 1·75. At the same time, Huggins finds very little, if any, sensible motion in the line of sight. Mr. Keeler finds as a mean from 10 nebulae 5005·68, magnesium being, according to his measurement, 5006·36, a difference of ·68. These latter observations completely invalidate Huggins's evidence on this point, especially as Mr. Keeler recognizes a motion of recession for the Orion nebula of 10·7 miles per second.

Mr. Gore ought to have recorded the fact that in Keeler's observations the comparisons for different nebulae gave the magnesium sometimes more refrangible and sometimes less refrangible than the nebular line. Later observations of Keeler, "corrected for the earth's orbital motion and the sun's motion," give the nebular line a wave-length of 5005·93, *i.e.* only ·43 from the magnesium. Assuming Keeler's latest results as perfectly correct, and placing his position at Charing Cross, while representing the position found for this line by Dr. Huggins in 1868 at St. Paul's Cathedral, we find Dr. Huggins's limiting positions in 1889 as the extreme east and extreme west ends of Green Park, his 1890 position in the middle of Green Park, while the magnesium fluting will be at Cecil Street. When we consider that a motion in the line of sight of less than twenty miles per second will make the nebular line and the magnesium fluting absolutely coincident, that the rate of the sun's motion in space is estimated but not absolutely known, that these measurements are probably the most difficult of all astronomical observations, and that every increase of power and accuracy has brought the lines closer together, we are certainly *not* justified in stating that the "weight of evidence" is "against the truth of the hypothesis." The differences in recorded wave-lengths of well-known solar lines by experienced observers are in many cases greater than the difference in question here.

Mr. Gore regards the dispersion used by Prof. Lockyer as insufficient, and yet he records that sixteen prisms were used by Lockyer in some of his observations of the coincidence of the nebular line with magnesium, so that his dispersion was actually greater than that used by Dr. Huggins, and two-thirds that of Mr. Keeler, whose dispersion equalled twenty-four prisms.

The objections to that portion of the meteoritic hypothesis which deals with the meteoritic origin of the lines in the auroral spectrum do not in any way affect the main hypothesis. That this subject is unimportant is distinctly recognized by Prof. Lockyer, "Meteoritic Hypothesis," p. 97, where he claims that "certainly the coincidence is such as to justify us in regarding meteoritic dust as the origin of the spectrum *until a better and more probable origin is demonstrated.*"

We are told (p. 122) that Mr. Monck objects to Lockyer's hypothesis, because it contains no explanation of "why all the planets and asteroids and the great majority of the satellites revolve in the same direction, why the orbits of the larger bodies of the system deviate so little from the circle and why they are so nearly in the same plane." This was asked in 1890; and yet Prof. G. H. Darwin had in 1888 shown that a swarm of meteorites which, on the meteoritic hypothesis would form a nebula,

may be considered as a gas, and therefore any answer that the nebular hypothesis can give to these questions will also apply to the meteoritic hypothesis.

Such puerile suggestions as that the meteorites used by Prof. Lockyer "*may have been*" of terrestrial origin: "that meteor clouds dense enough to produce the requisite amount of light by their collisions would also be dense enough to intercept *a great part of it* again on its way to the earth" (the italics are ours); and objections based on Mr. Monck's interpretation of Prof. Newton's calculations, and on opinions to which Mr. Monck "*inclines*" as to the origin of certain comets, are evidence that Mr. Gore has not hesitated to avail himself of anything that in any way seems to disagree with the meteoritic hypothesis. The whole of the "objections" of the "opponents" of Prof. Lockyer recorded by Mr. Gore are on matters of secondary importance, and have been insisted upon by him owing to his complete misconception of the theory. As a guide to the meteoritic hypothesis his chapter is misleading, and utterly valueless either as exposition or as criticism.

After his account of the meteoritic hypothesis Mr. Gore abruptly turns to a comparison of the various drawings that have been made of the Milky Way, and gives an interesting and valuable summary of the present state of our knowledge as to star distribution and movement and the construction of the Universe. For this portion of the book we have nothing but praise. It is carefully written and copiously illustrated. Mr. Gore has evidently taken the word "visible" in its widest possible sense, for he includes not only things visible to the retina of the eye, but those visible to the retina of the camera; and six excellent reproductions of photographs of nebulae and stars clearly demonstrate the superiority of the latter for astronomical purposes. It is probable that the use of photography in the preparation of complete charts of the Milky Way will throw much new light upon many of the points discussed in this portion of the book, and may profoundly modify many of the views at present held; but in presenting a clear and concise account of the present state of our knowledge Mr. Gore has made a valuable addition to the literature of the subject. An appendix, in which are given various calculations and tables involved in the discussion of several points raised in the book, and a useful index, complete the volume.

A. TAYLOR.

THE IRON MANUFACTURE IN AMERICA.

On the American Iron Trade and its Progress during Sixteen Years. By Sir Lowthian Bell, F.R.S. (Edinburgh and London: Ballantyne, Hanson, and Co.)

IT is impossible, in the limited space at our disposal, adequately to review this remarkable book, in which no branch of a very comprehensive subject appears to have escaped the author's close attention.

So full of detail and so exhaustive of the subject-matter are the various sections into which the work is divided, that we can do little more than glance at the numerous subdivisions.

The first section, dealing with international trade, dis-

cusses at length the American policy of protection. Comparison is made of American exports as affected by British free trade. Then follows a series of short articles on various subjects—the Anglo-American, imports of tinplates from this country, imports and exports of both countries, America as consumer and as exporter, and other important matters. By way of illustration copious tables are adduced with the author's deductions therefrom, and these will well reward the closest attention.

Section 2 deals with the relative cost of the necessities of life in various mining and metallurgical localities :—

"In the United States the manufacturers are enriched at the expense of the agriculturist and of other consumers. Some time before the abolition of protective duties in the United Kingdom years of scanty harvests entailed a great amount of misery among the labouring population of these islands, and at all times the landed interest by the protection granted to it by law, imposed a burthen upon industry generally. This relation between land and industry is now, as we have seen, reversed in the United States, by which, according to our views, the manufacturers are enriched at the expense of the agriculturists and of other consumers.

"Circumstances have greatly changed since the repeal of the corn laws, and the general introduction of free trade in the British Isles, for we have a people, the largest food importers in the world, obtaining their supplies 3000 miles from where they are grown, frequently at prices as favourable as those charged in the cities of America itself."

Sir Lowthian Bell appears to grasp fully a difficult situation, and gives a fair summary of the relative economic position of the two countries, and though his views will hardly be endorsed in their entirety by Americans, the present statement of them cannot fail to strengthen the movement now in progress towards a modification of the existing fiscal policy.

It is somewhat out of our province here to comment upon the protective policy so ardently advocated in America, but we are of opinion that had iron manufacturers in the States adopted, even partially, our policy of free competition, they and their *employés* would now have been in a stronger position, and would have had a better prospect of successfully competing with us. It is possible that the very natural desire to foster the home industry has carried them a little too far.

In the next section the assemblage of materials on American is compared with that on British railways in an exhaustive manner.

Section 5 treats of the iron ores of the States, and is fully illustrated with maps, topographic and geological, together with the coal fields. The quantities raised at different periods are given, and show that in ten years the production of ore has been fully doubled. This is followed by a detailed account of the mines and costs of working. Pages 96-104 contain some interesting speculative matter on the genesis of iron ores; the cost of raising ore, together with chemical analyses, is compared with that of Great Britain and other countries. The importance of having iron free from phosphorus is shown. It is noted that iron ore suitable for the Bessemer acid process has been imported. In 1880 only 27·35 per cent. of native ore was deemed suitable and raised for this purpose.

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Treating of raw material in the States, the writer gives a vivid picture of the boundless wealth of both ore and fuel existing within a limited area. In the great Lake district there is a wide strip of country over 1000 miles long, where ore is found, and this is insignificant when compared with the immense resources of fuel. The origin of natural gas, petroleum, and its uses receive attention—"natural gas is not a suitable form of fuel for the blast furnace."

Section 9, on the manufacture of coke, is interesting. At the outset coke is defined and compared with its analogues—anthracite or native coke. The losses necessarily entailed in the manufacture of coke are discussed, together with modes of minimizing them. It is shown that it is impossible to utilise the gases evolved in coking or heating coal in the blast furnace, and how slowly this was realized in early practice.

Here the author's ripe experience comes into play. The *rationale* of coking is tersely put, together with the methods dealing with the utilization and recovery of the ammonia, tar, &c., the products of the destructive distillation of coal, "or coking," with special appliances adapted for this purpose. The comparative merits of hard and soft coke in the blast furnace are discussed. Commercial details are appended, which speak for themselves, and which appear accurate.

From the section on the manufacture of pig iron it may be gathered that the gigantic methods of procedure, and the enormous energy displayed in the business of the American iron manufacture, leave the average cautious Englishman in the rear. There is, however, the reverse side for consideration: it is questionable whether even the magnificent results before us have not been purchased at too great a cost. Enormous quantities of iron have without doubt been turned out, such as would never have been dreamt of here; but it would seem that authorities are not yet in agreement as to the relative merit of English and American practice. So far our American cousins appear satisfied, pointing triumphantly to the saving of both time and material accruing from their present practice. At the Edgar Thompson Works (page 170) one of the furnaces ran 2462 tons of iron in one week, and showed an average make of 2813 tons per week with an expenditure of only 16·80 cwts. of coke per ton of iron. One needs, however, only to take Sir L. Bell's elaborate demonstration of the laws which govern the consumption of fuel in the blast furnace, and its utilization for the reduction of the ore, to see clearly that the above production is scarcely in the domain of practical work, carried out under ordinary conditions with average ores and fuel. Also (p. 162) he remarks, if Great Britain fails to offer striking examples such as are described by Mr. Potter and Mr. Gayley, yet, all things considered, a more uniform as well as loftier pitch of excellence in British furnace work can be proved.

Our space does not admit of a complete statement of Sir L. Bell's proofs; shortly, he first tabulates the work done at Middlesbrough with that of the Pittsburgh blast furnace, and absolutely demonstrates that the large makes are not altogether due to superior practice. A perusal of the tabular statement given satisfactorily accounts for the larger consumption of fuel in the English furnace.

The poorer ore of Cleveland consumes 3.48 cwt. of coke, as against only 1.42 cwt. in the richer ore used at Pittsburg for the future of the slag.

The quantity of slag determines the fuel required for its consumption, and here is the chief difference in the amount of fuel required, amounting to 2.06 cwts. The Clarence furnace consumed 19.99 cwt. of coke per ton of iron; the Pittsburg furnace consumed 16.80, difference 3.19, and deducting 2.06 from 19.99 cwt. = 17.93, showing an excess of 1.13 against the English furnace. This is practically the only margin we have for economy in the other sources of waste tabulated in Sir L. Bell's comparison of heat distribution.

A positive saving is effected of only 1.13 cwt., and reasons are given showing that, all things considered, this may be counterbalanced by the increased expenses incurred in American practice. As instance pp. 172-174 there are now four furnaces in action at the Clarence works performing duty well after 17½ years' service, as against the hard-driven furnaces in America with lining worn out, and useless in one-sixth of the period.

The limitation is well-defined in the following words, pp. 182-183:—

"As one who has been fifty years at blast furnaces, I am greatly impressed with the pitch of excellence to which the Americans have brought this useful invention.

"While saying so much I have not in my mind the enormous makes.

"In respect to this we must remember that neither in materials nor in labour can we look for any economy in this country.

"On the subject of large makes I must admit that I failed to shake the belief of my friend, Mr. E. C. Patter, that there is a great advantage in tasking the endurance of the furnace to the extent of reducing it to a wreck about every three years.

"I cannot say I am quite a convert to his creed, but recent experience, and the unswerving conviction of my American friends, have raised in my mind the disposition to make a trial of Cleveland ironstone, on what I have thought a questionable mode of action."

The question of heat intensity, or actual temperature, which must vary with the rate at which the fuel or coke is consumed, has not been mooted, and we admit there is no positive reason why it should.

Yet it is evident that a certain fuel—coke, for instance—may be so burnt as only to give a heat intensity barely sufficing for the fusion of lead. On the other hand, it may be so manipulated, *i.e.* rapidly consumed by a quick draught or forced blast "as to attain a heat intensity (temperature) sufficing for the fusion of pig iron."

Working with high pressure blast and driving in a large volume of air (87.15 cwts. Clarence, as against 71.20 cwts. Pittsburg, see p. 172), the heat intensity must be greater in the latter instance, and must, "according to the law of heat exchanges," result in the more rapid economic fusion of iron in the hearth, also intensifying the usual chemical reactions. This seems worth consideration; temperature is an important factor—in saying this it must not be inferred that the estimation of the calories which a given fuel evolves, and their distribution, must be

set aside; on the contrary, they remain the fundamental basis of any study bearing on the economic uses of fuel. Finally, one gathers on the whole that American practice is not universally superior to ours, and competent authorities are as a rule inclined to a compromise. In other words we might graft or partially adapt their practice to ours, so reaping the benefits of both; for something may be urged in favour of either system.

JOHN PARRY.

A COUNTY FAUNA.

The Fauna and Flora of Gloucestershire. By Charles A. Witchell and W. Bishop Strugnell. (Stroud: James, 1892.)

IT would really be almost difficult to discuss this book seriously were it not that the publication of so ambitious a work as the *Natural History of a County* must always be regarded as a serious undertaking. The reader who has struggled through the volume will lay it down with a sigh—not of regret at leaving it, but at the thought that time has been wasted in its compilation.

A glance at the index is almost enough to condemn the book, without making any attempt at further acquaintance. Among nearly a score of errors in spelling, *subuteo*, *oesalon*, *tinninculus*, occur as three consecutive words. Nor is this carelessness by any means confined to the index. Such blemishes disfigure the book from beginning to end; and when, among a host of errors, we find such mistakes as *haliotide* and *helliborus*, we can hardly ascribe all the blame to the printer. The compilers usually give us "Cotteswold," but in the introduction the name is spelt "Cotswold," and there are pages on which both forms occur—in one case only a line apart.

A more serious fault is the want of balance in the work. The space allotted to birds occupies eighty-two pages, while the chapter on ants takes up nearly twenty, and that on wasps and bees close upon fifty pages. We may say at once that the two latter are so good, and stand out in such marked contrast to the rest of the work that, in spite of their disproportionate length, we hardly grudge a line of the room they occupy. Perhaps, however, it is the length of these papers which makes one of the writers on mosses omit "many other interesting species," for want of space. Another contributor calls his list of fungi "short and very imperfect." If the list is as complete as it is possible to make it, no one can fairly complain of its shortness; but surely it is scarcely worth while to print an avowedly imperfect list in what professes to be a County Flora.

The fauna opens with a brief account of the bats, a mere list of names, among which we look in vain for any evidence of observation. The notices of the quadrupeds contain some interesting particulars, but they present little that is new. In the article on the badger a good deal of information is given on the authority of a gentleman who appears to think no observations but his own are worthy of credence. One of his own observations is thus worded: "Any one who has caught badgers at night knows only too well that it is certain death to a dog